

# **The Stevens Integrated Maritime Surveillance and Forecast System: Expansion and Enhancement**

Michael S. Bruno and Alan F. Blumberg  
Center for Maritime Systems  
Stevens Institute of Technology  
Castle Point on Hudson  
Hoboken, New Jersey, 07030  
phone: 201-216-5338 fax: 201-216-8214 email: [mbruno@stevens.edu](mailto:mbruno@stevens.edu)

ONR Grant No. N00014-03-1-0633

## **LONG-TERM GOALS**

The long-term goal of the project is to develop an advanced, integrated system of oceanographic, meteorological, and vessel surveillance sensors and littoral ocean forecasting models to allow for the real-time assessment of ocean, weather, environmental, and vessel traffic conditions throughout the New York Harbor region, and the forecast of conditions in the near and long-term and under specific threat scenarios. In the long-term, the observation and modeling systems will be linked in a unique fashion, whereby the model forecast system will be enhanced by data assimilation, and the observing system will be enhanced by model-directed observations and model-assisted data interpolation.

## **OBJECTIVES**

During the year under report, the objective was to enhance and expand an existing observing and forecasting system of New York Harbor that is used to support both safe navigation and port security. The system is structured to enable real-time and ongoing changes to the sampling scheme of the observation system, based on model forecasts and/or user intervention. Primary objectives of the past year's effort included the installation of an HF RADAR system to provide synoptic measurements of surface currents in the Lower Harbor, improved wireless data transmission, installation of a CTD sensor on a Harbor vessel, and the development of sophisticated model-assisted data interpolation and graphics.

## **APPROACH**

The observing system development is being coordinated by M. Bruno. This effort includes the development and deployment of ocean and weather sensors, including land-based salinity, temperature, turbidity, water level, current, and weather monitoring sensors at shoreline locations throughout the Harbor; buoy-based salinity and temperature sensors; an HF RADAR system in the Lower Harbor; and several vessel-based salinity and temperature sensors. The HF RADAR system is a joint effort with a separately-funded group at the Rutgers University Institute for Marine and Coastal Sciences.

The model forecast system is being coordinated by A. Blumberg. This effort includes the development of a very high-resolution, 3-D model of the entire Hudson-Raritan Estuary and Long Island Sound, linked at the ocean boundary to a model of the New York Bight. The model is centered on the use of a high resolution application of the Princeton Ocean Model (Blumberg and Mellor, 1987). Water

Report Documentation Page				Form Approved OMB No. 0704-0188	
Public reporting burden for the collection of information is estimated to average 1 hour per response, including the time for reviewing instructions, searching existing data sources, gathering and maintaining the data needed, and completing and reviewing the collection of information. Send comments regarding this burden estimate or any other aspect of this collection of information, including suggestions for reducing this burden, to Washington Headquarters Services, Directorate for Information Operations and Reports, 1215 Jefferson Davis Highway, Suite 1204, Arlington VA 22202-4302. Respondents should be aware that notwithstanding any other provision of law, no person shall be subject to a penalty for failing to comply with a collection of information if it does not display a currently valid OMB control number.					
1. REPORT DATE <b>30 SEP 2005</b>		2. REPORT TYPE		3. DATES COVERED <b>00-00-2005 to 00-00-2005</b>	
4. TITLE AND SUBTITLE <b>The Stevens Integrated Maritime Surveillance and Forecast System: Expansion and Enhancement</b>				5a. CONTRACT NUMBER	
				5b. GRANT NUMBER	
				5c. PROGRAM ELEMENT NUMBER	
6. AUTHOR(S)				5d. PROJECT NUMBER	
				5e. TASK NUMBER	
				5f. WORK UNIT NUMBER	
7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES) <b>Stevens Institute of Technology, Center for Maritime Systems, Castle Point on Hudson, Hoboken, NJ, 07030</b>				8. PERFORMING ORGANIZATION REPORT NUMBER	
9. SPONSORING/MONITORING AGENCY NAME(S) AND ADDRESS(ES)				10. SPONSOR/MONITOR'S ACRONYM(S)	
				11. SPONSOR/MONITOR'S REPORT NUMBER(S)	
12. DISTRIBUTION/AVAILABILITY STATEMENT <b>Approved for public release; distribution unlimited</b>					
13. SUPPLEMENTARY NOTES <b>code 1 only</b>					
14. ABSTRACT <b>The long-term goal of the project is to develop an advanced, integrated system of oceanographic, meteorological, and vessel surveillance sensors and littoral ocean forecasting models to allow for the real-time assessment of ocean, weather, environmental, and vessel traffic conditions throughout the New York Harbor region, and the forecast of conditions in the near and long-term and under specific threat scenarios. In the long-term, the observation and modeling systems will be linked in a unique fashion, whereby the model forecast system will be enhanced by data assimilation, and the observing system will be enhanced by model-directed observations and model-assisted data interpolation.</b>					
15. SUBJECT TERMS					
16. SECURITY CLASSIFICATION OF:			17. LIMITATION OF ABSTRACT <b>Same as Report (SAR)</b>	18. NUMBER OF PAGES <b>13</b>	19a. NAME OF RESPONSIBLE PERSON
a. REPORT <b>unclassified</b>	b. ABSTRACT <b>unclassified</b>	c. THIS PAGE <b>unclassified</b>			

surface elevation and three-dimensional fields of currents, temperature, salinity, and water turbulence are calculated in response to meteorological conditions, freshwater inflows, tides, temperature and salinity at the open boundaries.

Both the observations and the model forecasts are distributed in near real-time to the public via the Stevens web site, using user-friendly graphical interfaces, at <http://onr.dl.stevens-tech.edu/webnyhos3/>.

## **WORK COMPLETED**

The work completed includes:

### **Observing System**

Real-time oceanographic and weather information within the Estuary is obtained using various sensors placed at strategic locations; see Figure 1 for station locations. The sensor design and network configuration were patterned after an existing Stevens system on the New Jersey coast (Bruno, et. al. 2001). The network sensors, all of which provide their data in real-time, include:

- 7 shore-based salinity, temperature, turbidity, and water level sensors
- 2 moored platforms containing salinity, temperature, turbidity, and pressure sensors
- 2 Acoustic Doppler Current Profilers (ADCPs)
- Vessel-based conductivity and temperature sensors
- 6 weather stations providing continuous observations of local meteorological conditions
- A CODAR (HF RADAR) system located on the southeast shore of Staten Island (see Figure 1) that provides the coverage necessary to enable surface current and wave measurements across much of the lower Harbor.

Newly expanded wireless data transmission capabilities have significantly improved data transmission rates and reliability. Issues such as wireless security and integrity have been addressed. Discussions with data users, including US Coast Guard Sector New York and the marine transportation industry, have led to improved web site data delivery, including new graphics that employ the model nowcasts to create color-coded maps of ocean properties from the discrete sensor data (see Bruno and Blumberg, 2004).

### **Prediction System**

The prediction system is fully operational, and provides 72 hour simulations - 24 hours in the past (the hindcast mode) and 48 hours into the future (the forecast mode). The nowcast is obtained at the conclusion of the hindcast part of the cycle and a file is written out which forms the basis for the next cycle. The forecast simulations are performed using forecasted forcing functions except for the river flows, which are based on daily persistence. The modeling system saves the proper hydrodynamic information for a restart. A smooth and seamless execution occurs to start the next cycle, which is scheduled to start 24 hours later. Three-dimensional fields of salinity, temperature, and currents and

two dimensional fields of water level, significant wave height, period and direction are archived every 30 minutes.

## RESULTS

The integration of the observing system and the modeling system has significantly improved the performance of both. The forecast estimate of present conditions is improved by using the observations, which are continually available in real-time throughout the forecast period. The observation system employs the model to facilitate the creation of color-coded data “maps” for each measured parameter. Every 30 minutes a map of “Present Conditions” is prepared by assimilating all of the available data for that 30 minute period with the appropriate forecast. An objective optimal interpolation technique is used to create the assimilated distribution. In addition to being posted to the Internet, these distributions are saved for use with the next cycle of the prediction system. Figure 2 illustrates “Present Conditions” of surface salinity in the NY/NJ Estuary for 23 August, 2005, 12:11 EDT. The website delivers the present and forecast conditions, at <http://onr.dl.stevens-tech.edu/webnyhos3/>.

Preliminary field validation experiments have been conducted to assess the skill of the HF RADAR system in providing high-resolution measurements of the surface currents in the Lower Harbor. Of particular interest is the connection of the Estuary to the Atlantic Ocean via the Sandy Hook – Rockaway Transect. Figure 3 illustrates the results of the preliminary assessment of signal strength from the Stevens-Rutgers CODAR array. Figure 4 illustrates the August, 2005 surface currents in the main navigation channel (Ambrose Channel) entering New York Harbor. This channel is the primary hydrodynamic connection between the Estuary and the Atlantic Ocean. Work is continuing on comparing the CODAR measurements with ship-board current observations. A new vessel-based CTD sensor was put into operation, using the sightseeing sailing vessel Pioneer, which is based at the South Street Seaport Museum on the East River in Lower Manhattan. The vessel is presently transmitting (via cellular wireless) real-time measurements of near-surface (1 meter) salinity, temperature, and dissolved oxygen. Figure 5 is an illustration of the GPS-generated ship track of the Pioneer during a recent time period, August 19 to August 22, 2005. Note the significant spatial coverage of the Harbor region in the vicinity of the Battery – the location of the confluence of the Hudson and East Rivers and therefore an area of dynamic significance. Figure 6 illustrates the real-time measurements of near-surface temperature along the route as the Pioneer was underway on August 24, 2005.

In order to firmly establish the credibility and robustness of the modeling system, the assessment of model skill must be an ongoing task. As the forecasts proceed, comparisons between model results and observations are being made. Figure 7 illustrates a time history over 45 days of water level, temperature and salinity in the Hudson River at Castle Point, NJ.

## IMPACT/APPLICATIONS

The work presented here provides a major step forward to the operational (two-way) coupling of real-time ocean and weather observation systems with a modeling system. The coupled system has also served as a valuable vehicle to enable the development of reliable, operational fixed and vessel-based observation systems. NYHOPS provides a wealth of real-time data and accurate forecasts in the waters of New York and New Jersey. This information is now available to serve the maritime user community in the same way that weather forecasting has served the on-land population. All of the data is available over the Internet 24 hours a day by means of weather forecast-like maps that can be used effectively by

Harbor pilots, sailors, power boaters, swimmers, and fishermen as well as port security officials and emergency management personnel.

The observational network and modeling system are parts of the integrated, sustained ocean observing system envisioned by the National Oceanographic Partnership Program (NOPP), under the OCEAN.US office, and the Integrated Ocean Observing System (IOOS). The PI's have been active participants in the leadership of the Mid-Atlantic Coastal Ocean Observing Regional Association (MACOORA), now designated as a formal Regional Association under the IOOS program.

#### **RELATED PROJECTS**

None

#### **REFERENCES**

Blumberg, A. F., and G. L. Mellor, 1987: A description of a three-dimensional coastal ocean circulation model. *Three Dimensional Coastal Models*, Coastal and Estuarine Sciences, 4, N. S. Heaps (ed.), Amer. Geophys. Union Geophysical Monograph Board, 1-16.

Bruno, M.S., O. G. Nwogu, K.L. Rankin, and T. O. Herrington, 2001. "Real-Time Coastal Monitoring and Forecasting System : Preliminary Results", International Conference on Coastal Engineering, Vol 1, 283-291, ASCE.

Bruno, M. S. and A. F. Blumberg, 2004: An Urban Ocean Observatory – Real-time Assessments and Forecasts of The New York Harbor Marine Environment, *Sea Technology*, 45, 27-32.

#### **PUBLICATIONS**

1. "An Urban Ocean Observatory – Real-time Assessments and Forecasts of The New York Harbor Marine Environment", M. S. Bruno, A. F. Blumberg, *Sea Technology*, 45, 27-32, 2004.
2. "Mixing in the Hudson Estuary: The Role of Estuarine Circulation and Tidal Trapping," F. L. Hellweger, A. F. Blumberg, P. Schlosser, and D. T. Ho. *Estuaries*, 27, 527-538, 2004.
3. "A Particle-Tracking Model for Predicting Entrainment at Power Plants on the Hudson River," A.F. Blumberg, D. J. Dunning, H. Li, R.C. Geyer, and D. Heimbuch. *Estuaries*, 27, 515-526, 2004.
4. "Wave Breaking and Ocean Surface Layer Thermal Response," G. L. Mellor and A. F. Blumberg. *J. Phys. Oceanogr.*, 34, 693-698, 2004.
5. "Geomorphological and Meteorological Control of Estuarine Processes – Modeling Analyses using a High Resolution 3D Hydrodynamic Model", A.K.M.Q. Ahsan and A.F. Blumberg, A. J. Thuman, and T. W. Gallagher. *J. Hydraulic Engineering*, 131, 259-272, 2005.
6. "The Influence of Centrifugal and Coriolis Forces on the Circulation in a Curving Estuary", N. Georgas and A. F. Blumberg. *Estuarine and Coastal Modeling*, ASCE, 541- 558, 2004.
7. "Evaluation of the Northern Gulf of Mexico Littoral Initiative Model Based on the Observed Temperature and Salinity in the Mississippi Bight". Vinogradova, N., S.Vinogradov, D.Nechaev,

V.Kamenkovich, A.F.Blumberg, Q.Ahsan, and H.Li, Marine Technology Society Journal, 39 (2), 25-38. 2005.

8. “Hydrodynamics of the Hudson River Estuary”, A. F. Blumberg and F. L. Hellweger. In: Hudson River Fishes and their Environment, Waldman, J., K. Limburg, and D. Strayer, Eds. American Fisheries Society, Alpharetta, Georgia, (accepted), 2005.

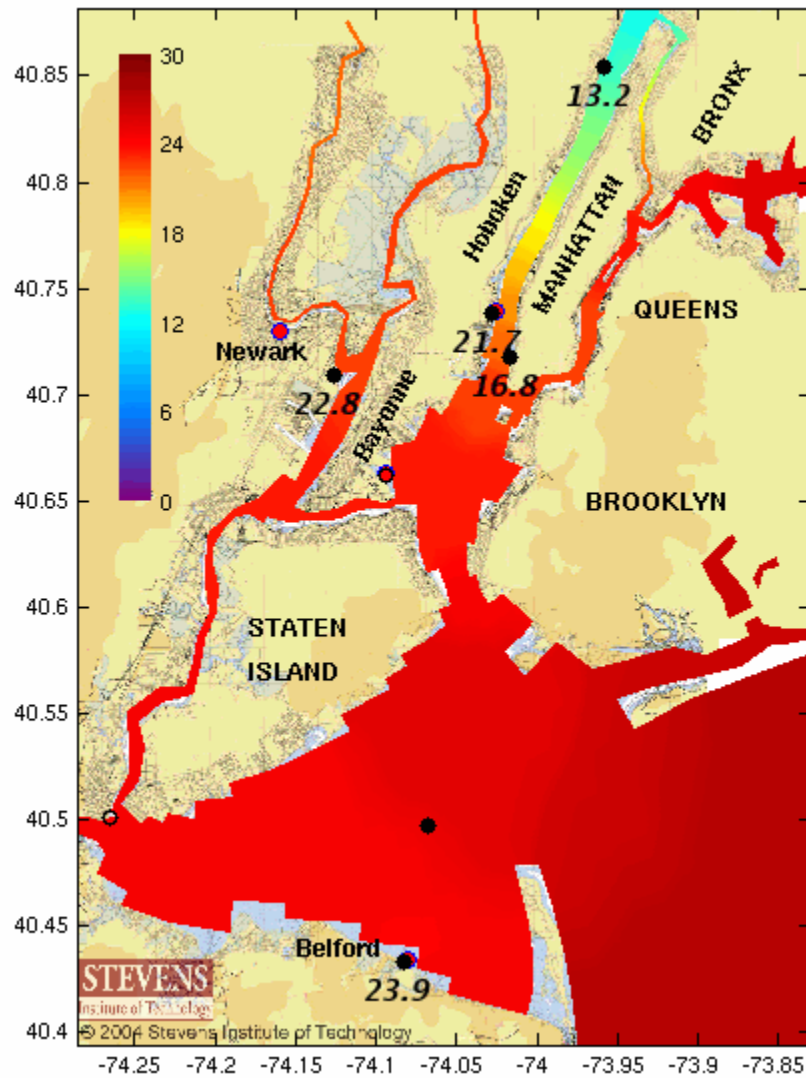
#### **HONORS/AWARDS/PRIZES**

None.



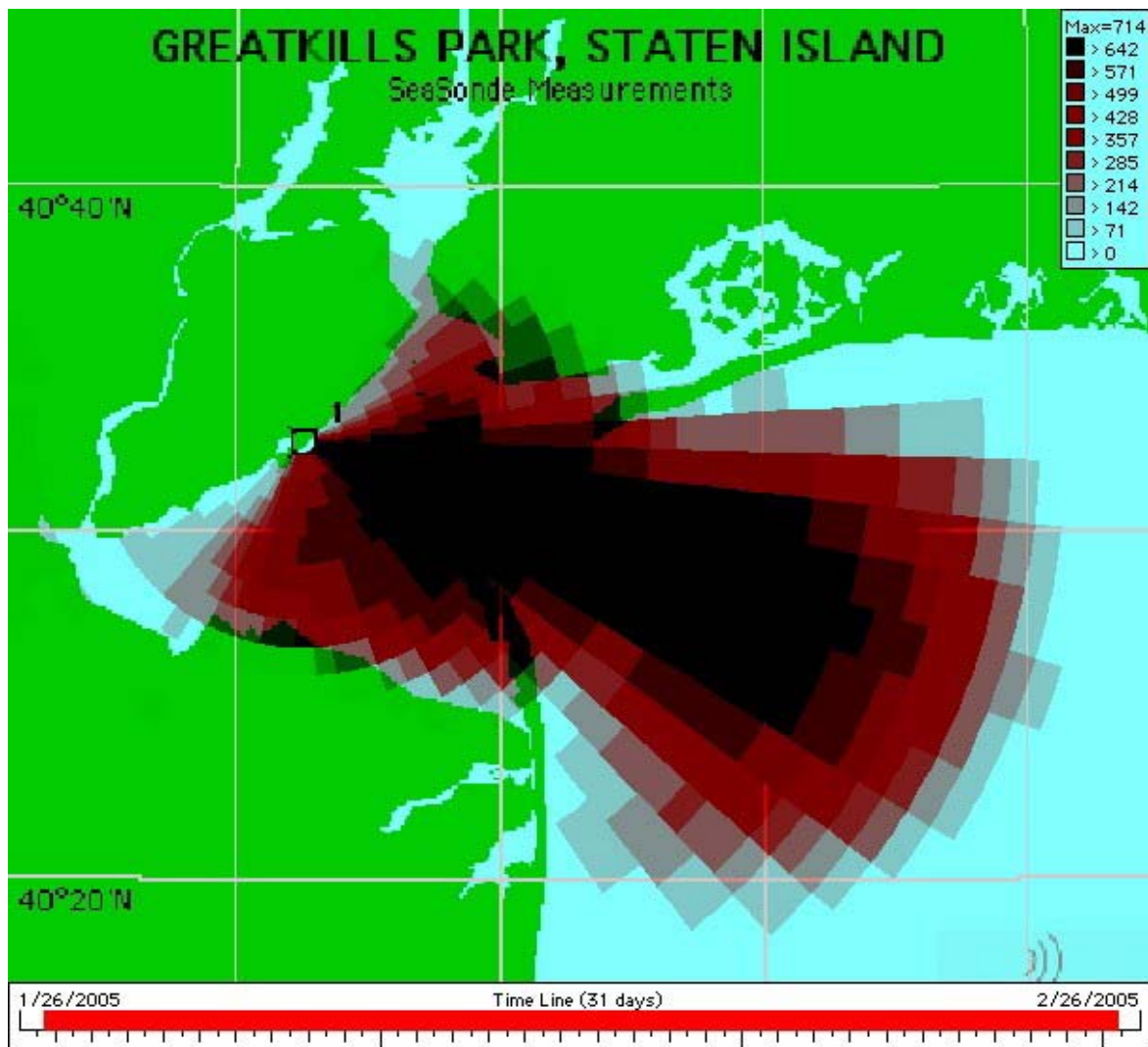
***Figure 1. Location of sensors in the NYHOPS sensor network. Several of these sensors are owned and maintained by NOAA/NOS, Rutgers University and The River Project. Supplementing this network are observations made by several vessels which travel throughout these waters on a routine basis.***



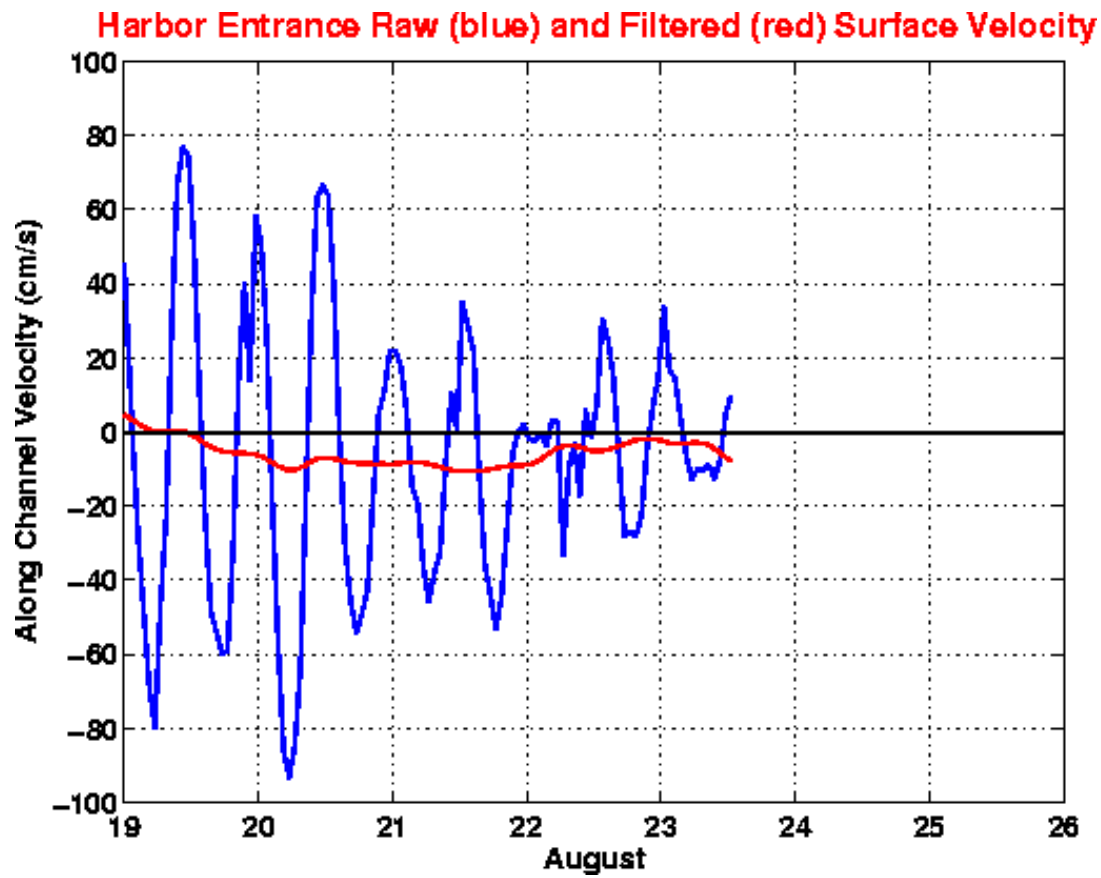


*Figure 2. The surface salinity in the NY/NJ Estuary subdomain on 23 August, 2005, 12:11 EDT. The spatial distribution is created using real-time data from the sensor network, the forecasted field that is available every 30 minutes, and an objective interpolation technique. The dots represent the locations of the sensors.*



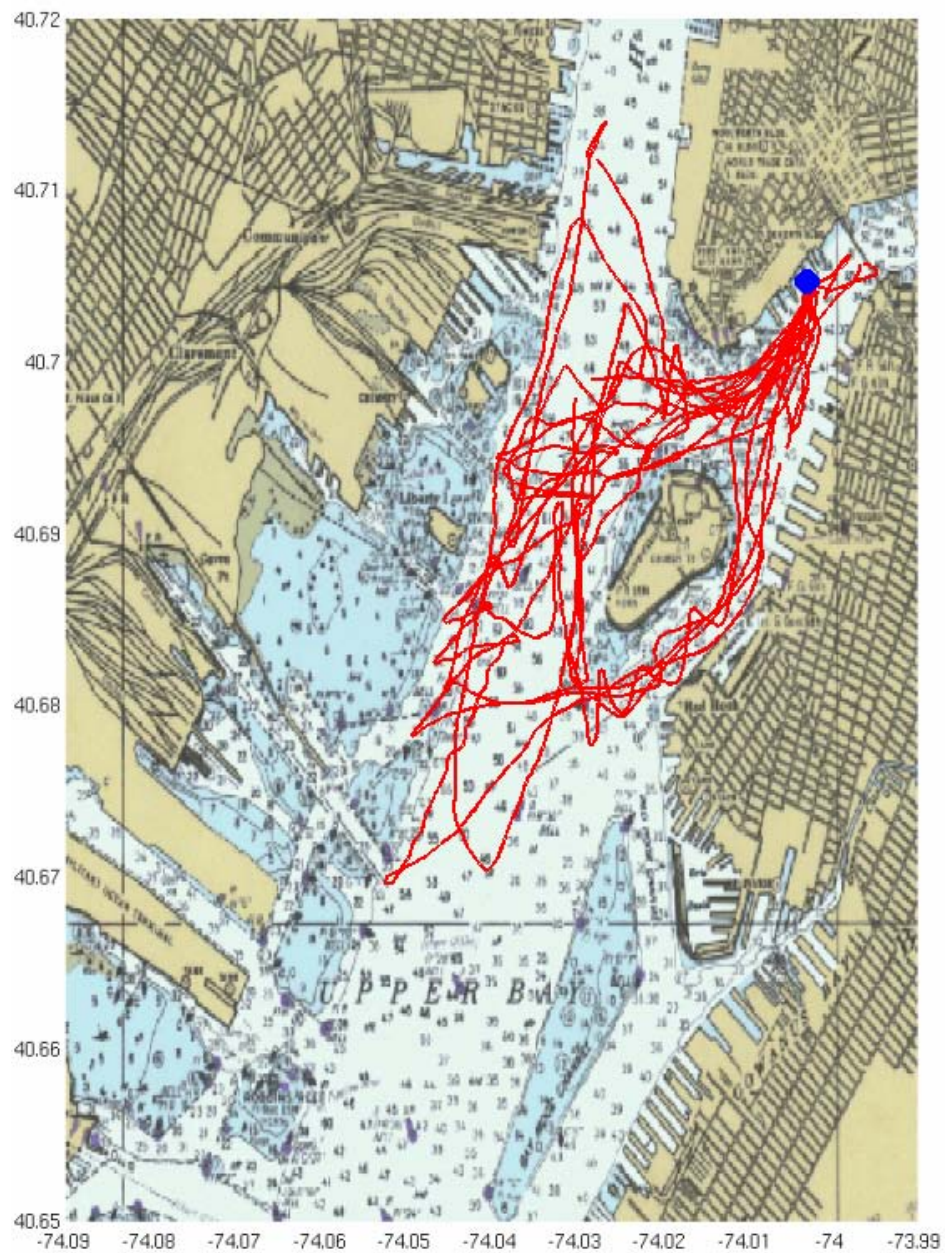


*Figure 3. Plot of signal strength from the 3-CODAR Stevens-Rutgers array, averaged over 31 days.*



*Figure 4. Time series of the along-channel (east-west) surface current velocity at the Sandy Hook – Rockaway Transect during the month of August, 2005. Positive velocities are directed into the Harbor (west). The velocities are representative of the surface current in the Ambrose navigation channel.*

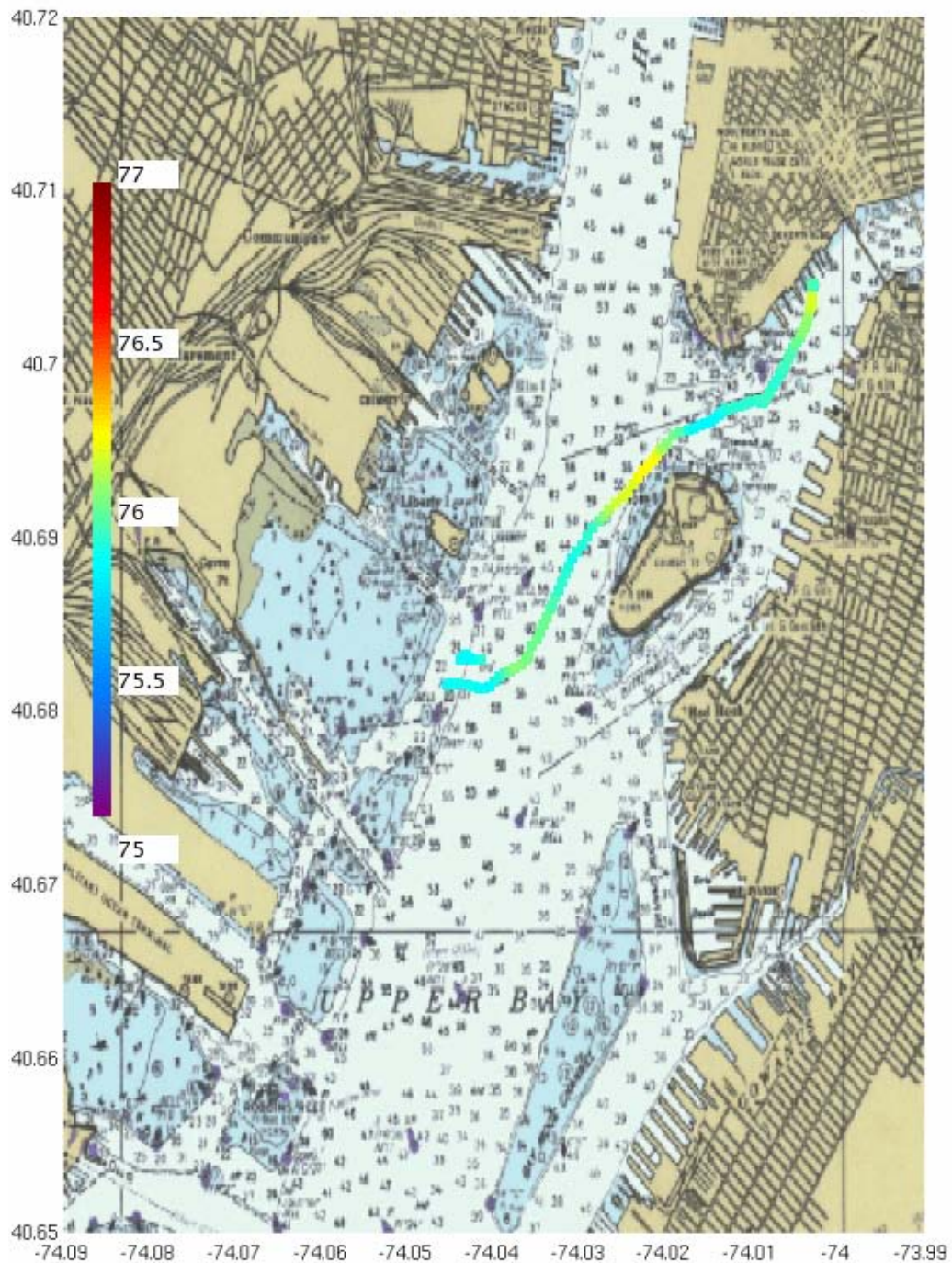
Track of Pioneer from 2005-08-19 00:00 to 2005-08-22 00:00 (ET)



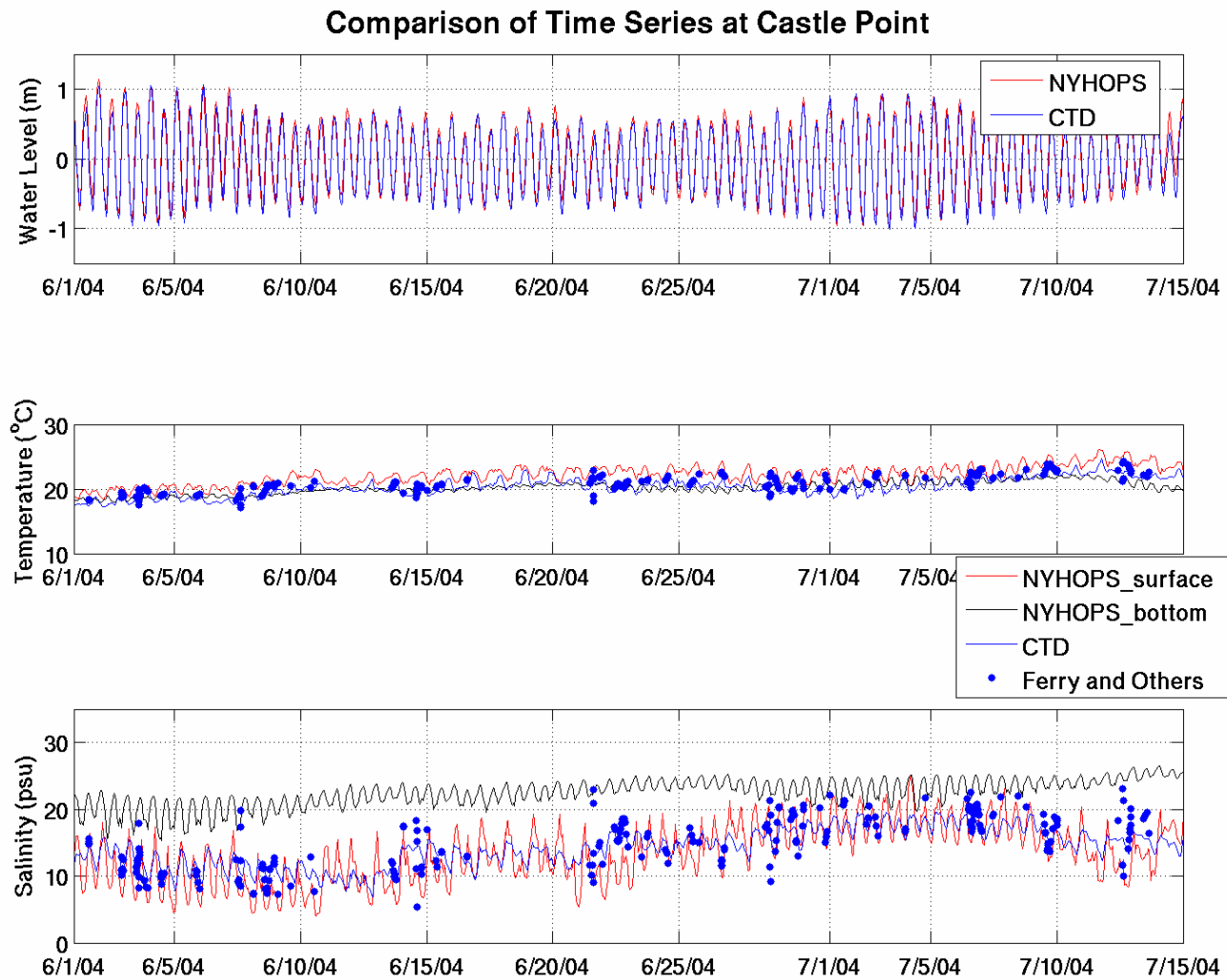
***Figure 5: Track of the instrumented vessel, the sailing ship Pioneer, during the period August 19 to August 22, 2005.***



Surface water temperature (F) from 2005-08-24 00:00 to 2005-08-24 14:24 (ET)



**Figure 6.** Real-time measurements of near-surface temperature along the route of the instrumented vessel Pioneer on August 24, 2005.



***Figure 7. This NYHOPS web site graphic provides a time history over 45 days of water level, temperature and salinity in the Hudson River at Castle Point, NJ one of 15 stations available to the user.***